

Course Syllabus

Course Information

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| <i>Course Number/Section</i> | CS 7301 - 002 |
| <i>Course Title</i> | Physics-Based Modeling and Simulation |
| <i>Term</i> | Spring 2009 |
| <i>Days & Times</i> | MW 2:30 pm – 3:45 pm, ECSS 2.203 |

Professor Contact Information

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| <i>Professor</i> | Xiaohu Guo |
| <i>Office Phone</i> | 972-883-4723 |
| <i>Other Phone</i> | |
| <i>Email Address</i> | xguo@utdallas.edu , or Use WebCT e-mail tool |
| <i>Office Location</i> | ECSS 3.703 |
| <i>Office Hours</i> | Monday and Wednesday 3:45 pm – 5:00 pm (in my office) |
| <i>Other Information</i> | It is important to visit the course web page http://www.utdallas.edu/~xguo/CS7301.htm , and course WebCT frequently to check announcements, assignments, tips, FAQ, links, etc. |

Course Pre-requisites, Co-requisites, and/or Other Restrictions

Either one of the following courses: computer graphics (CS4361 / CS6366), computer animation (CS4392), geometric modeling and processing (CS6v81), or permission of the instructor. Students are expected to be familiar with calculus, algebra, geometry, basic physics, and good working knowledge of graphical programming (OpenGL or DirectX).

Course Description

The central theme of this advanced graduate course is on physics-based modeling and simulation, as well as their widespread applications in the entire spectrum of visual computing discipline. This course will cover the fundamental methods for describing and then applying rules to simulate various natural phenomena. Throughout this course, we take a unified physical approach to various visual computing fields such as computer graphics, animation, human-computer interaction, and virtual environment. Our goal is to familiarize students with state of the art theoretical and computational methods in physics-based modeling and simulation, with focuses on:

- Rigid body dynamics and motion
- Collision detection and response
- Particle system and interactions
- Deformable objects
- Continuum models
- Finite element method
- Numerical integration techniques
- Constraint systems
- Data-driven simulation

Student Learning Objectives/Outcomes

After successful completion of this course, the students will be able to:

- Explain general concepts related to physics-based modeling and simulation
- Be familiar with mathematical foundations for particle system, rigid body, deformable models, and their numerical integration techniques
- Understand the simulation pipeline, including finite element method, collision detection, collision response, etc.
- Use OpenGL/DirectX as a tool for creating physically realistic scenes
- Be well prepared for graduate research or work in graphical modeling and simulation

Required Textbooks and Materials

There is no particular textbook for this course because it is an advanced graduate course! But the following textbook will be suggested:

- Physics-Based Animation, by Kenny Erleben, Jon Sporring, Knud Henriksen, and Henrik Dohlmann, Charles River Media, 2005. ISBN: 1584503807.

The majority of the course material will come from the textbook, research papers, and some relevant reference books. Numerous slides and video clips will be shown. Students are advised to attend the class and follow the lecturing notes closely! A set of research papers and some relevant material from the following reference books (and conference proceedings and journals) will be presented.

- Interactive Computer Graphics: A Top-Down Approach Using OpenGL, 5th edition, E. Angel, 2008.
- Computer Animation: Algorithms & Techniques, 2nd edition, R. Parent, 1993.
- Curves and Surfaces for Computer Aided Geometric Design: A Practical Guide, 5th edition, G. Farin, 2001.
- Pyramid Algorithms: A Dynamic Programming Approach to Curves and Surfaces for Geometric Modeling, R. Goldman, 2002.
- Differential Geometry of Curves and Surfaces, M.P. do Carmo, Prentice--Hall, Englewood Cliffs, NJ, 1976.
- Introduction to Applied Mathematics, G. Strang, Wellesley Cambridge Press, 1986.
- Numerical Recipes 3rd Edition: The Art of Scientific Computing, W.H. Press, B.P. Flannery, S.A. Teukolsky, and W.T. Vetterling, 2007.
- Computer-Oriented Mathematical Physics, D. Greenspan, Pergamon Press, Oxford, 1981.
- Methods of Mathematical Physics, Vol I, Interscience, London. R. Courant and D. Hilbert, 1953.
- Classical and Computational Solid Mechanics, Y.C. Fung, P. Tong, 2001.
- The Finite Element Method (Third Edition), O.C. Zienkiewicz, McGraw--Hill, London, 1977.
- The Finite Element Handbook, H. Kardestuncer and D.H. Norrie, McGraw-Hill, 1987.

Relevant Conference Proceedings and Journals:

- Computer Graphics (Proceedings of ACM SIGGRAPH)
- IEEE Computer Graphics and Applications

- ACM Transactions on Graphics
- IEEE Transactions on Visualization and Computer Graphics
- Computer-Aided Design Computer Aided Geometric Design
- Graphical Models
- The Visual Computer
- Computer Graphics Forum
- IEEE Transactions on Pattern Analysis and Machine Intelligence
- IEEE Transactions on Medical Imaging
- Major conferences include Siggraph, Visualization, Eurographics, Pacific Graphics, Graphics Interface, Solid Modeling, Shape Modeling, I3D Symposium, CGI, ICCV, CVPR, etc.

Required Readings:

- D. Baraff, A. Wikin, and M. Kass, "Physically Based Modelling - Siggraph 2001 Course Notes"
 - Lecture B: Differential Equation Basics
 - Lecture C: Particle System Dynamics
 - Lecture D: Implicit Methods for Differential Equations
 - Lecture F: Constrained Dynamics
 - Lecture G: Rigid Body Simulation
- M. Mueller, D. James, N. Thuerey, and J. Stam, "Realtime Physics - Siggraph 2008 Course Notes"
 - Notes (Chapters 2-6)
 - Slides: Deformable Objects

Assignments & Academic Calendar

Topics, Reading Assignments, Due Dates, Exam Dates

| Class Schedule |
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| Introduction to Physics-Based Modeling and Simulation |
| Newtonian Dynamics |
| Particle System |
| Differential Equations |
| Implicit Solver |
| Solving Linear System |
| Rigid Body Simulation |
| Mass-Spring System |
| Finite Element Method |

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| Collisions |
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| Paper Presentations |
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| Final Project Presentation |

Important: The dates in this schedule may change due to the class level. If the class needs more time and examples to understand a concept I will modify the schedule. If the class is ready to skip a chapter or go faster I will modify the schedule. Therefore, it is the student's responsibility to check what we covered in class and the changes in the schedule announced during class.

Grading Policy

There will be No Midterm Exams and No Final Exams! However, this is a project-oriented course. Each student will be assigned two days during the semester during which they will present to the class a summary of the assigned readings for that day. The presentation should provide a technical overview of the paper, a description of how the paper fits into the broader context of the material covered in the course, and should pose some interesting questions or challenges for in-class discussion. Students taking the course for a letter grade will work individually or in a team of two to complete a course-related project. All project ideas are individually approved by the instructor. Proposals are due by mid-semester. The final grade will be based on paper presentations, project proposals, demos, presentations, and reports. The programming projects can be implemented in any of your preferred programming environment (e.g. Windows, C++, OpenGL). All the paper presentations and projects are mandatory. The final grade will be composed of the following three parts:

- Paper Reading and Presentation: 30%
- Course Project: 60%
 - Project proposal (10%)
 - Final demo and presentation (10%)
 - A working system and software codes (30%)
 - Final Project Report (10%)
- Class Attendance and Active Involvement: 10%

Course Policies

Make-up exams

No makeup exams for this course.

Extra Credit

No extra credit available for this course.

Late Work

No late work for this course.

Special Assignments

No special assignments for this course.

Class Attendance

I expect the students to **come to class**, read and study the materials and textbook. Download and print available materials from WebCT prior to coming to class. The class schedule specifies the chapters to read for each topic covered. Primary material of this course will come from the required textbook. In addition, material from recent articles or relevant reference books will be presented. Numerous slides and video clips will be

shown. Students are advised to attend the class and follow the lecture notes closely. It is the **student's responsibility** to check what we covered in class and the announcements during class if he or she did not attend.

Classroom Citizenship

Field Trip Policies / Off-Campus Instruction and Course Activities

No field trip for this course.

Student Conduct & Discipline

The University of Texas System and The University of Texas at Dallas have rules and regulations for the orderly and efficient conduct of their business. It is the responsibility of each student and each student organization to be knowledgeable about the rules and regulations which govern student conduct and activities. General information on student conduct and discipline is contained in the UTD publication, *A to Z Guide*, which is provided to all registered students each academic year.

The University of Texas at Dallas administers student discipline within the procedures of recognized and established due process. Procedures are defined and described in the *Rules and Regulations, Board of Regents, The University of Texas System, Part 1, Chapter VI, Section 3*, and in Title V, Rules on Student Services and Activities of the university's *Handbook of Operating Procedures*. Copies of these rules and regulations are available to students in the Office of the Dean of Students, where staff members are available to assist students in interpreting the rules and regulations (SU 1.602, 972/883-6391).

A student at the university neither loses the rights nor escapes the responsibilities of citizenship. He or she is expected to obey federal, state, and local laws as well as the Regents' Rules, university regulations, and administrative rules. Students are subject to discipline for violating the standards of conduct whether such conduct takes place on or off campus, or whether civil or criminal penalties are also imposed for such conduct.

Academic Integrity

The faculty expects from its students a high level of responsibility and academic honesty. Because the value of an academic degree depends upon the absolute integrity of the work done by the student for that degree, it is imperative that a student demonstrate a high standard of individual honor in his or her scholastic work.

Scholastic dishonesty includes, but is not limited to, statements, acts or omissions related to applications for enrollment or the award of a degree, and/or the submission as one's own work or material that is not one's own. As a general rule, scholastic dishonesty involves one of the following acts: cheating, plagiarism, collusion and/or falsifying academic records. Students suspected of academic dishonesty are subject to disciplinary proceedings.

Plagiarism, especially from the web, from portions of papers for other classes, and from any other source is unacceptable and will be dealt with under the university's policy on plagiarism (see general catalog for details). This course will use the resources of turnitin.com, which searches the web for possible plagiarism and is over 90% effective.

Email Use

The University of Texas at Dallas recognizes the value and efficiency of communication between faculty/staff and students through electronic mail. At the same time, email raises some issues concerning security and the identity of each individual in an email exchange. The university encourages all official student email correspondence be sent only to a student's U.T. Dallas email address and that faculty and staff consider email from students official only if it originates from a UTD student account. This allows the university to maintain a high degree of confidence in the identity of all individual corresponding and the security of the transmitted information. UTD furnishes each student with a free email account that is to be used in all communication with university personnel. The Department of Information Resources at U.T. Dallas provides a method for students to have their U.T. Dallas mail forwarded to other accounts.

Withdrawal from Class

The administration of this institution has set deadlines for withdrawal of any college-level courses. These dates and times are published in that semester's course catalog. Administration procedures must be followed. It is the student's responsibility to handle withdrawal requirements from any class. In other words, I cannot drop or withdraw any student. You must do the proper paperwork to ensure that you will not receive a final grade of "F" in a course if you choose not to attend the class once you are enrolled.

Student Grievance Procedures

Procedures for student grievances are found in Title V, Rules on Student Services and Activities, of the university's *Handbook of Operating Procedures*.

In attempting to resolve any student grievance regarding grades, evaluations, or other fulfillments of academic responsibility, it is the obligation of the student first to make a serious effort to resolve the matter with the instructor, supervisor, administrator, or committee with whom the grievance originates (hereafter called "the respondent"). Individual faculty members retain primary responsibility for assigning grades and evaluations. If the matter cannot be resolved at that level, the grievance must be submitted in writing to the respondent with a copy of the respondent's School Dean. If the matter is not resolved by the written response provided by the respondent, the student may submit a written appeal to the School Dean. If the grievance is not resolved by the School Dean's decision, the student may make a written appeal to the Dean of Graduate or Undergraduate Education, and the dean will appoint and convene an Academic Appeals Panel. The decision of the Academic Appeals Panel is final. The results of the academic appeals process will be distributed to all involved parties.

Copies of these rules and regulations are available to students in the Office of the Dean of Students, where staff members are available to assist students in interpreting the rules and regulations.

Incomplete Grade Policy

As per university policy, incomplete grades will be granted only for work unavoidably missed at the semester's end and only if 70% of the course work has been completed. An incomplete grade must be resolved within eight (8) weeks from the first day of the subsequent long semester. If the required work to complete the course and to remove the incomplete grade is not submitted by the specified deadline, the incomplete grade is changed automatically to a grade of **F**.

Disability Services

The goal of Disability Services is to provide students with disabilities educational opportunities equal to those of their non-disabled peers. Disability Services is located in room 1.610 in the

Student Union. Office hours are Monday and Thursday, 8:30 a.m. to 6:30 p.m.; Tuesday and Wednesday, 8:30 a.m. to 7:30 p.m.; and Friday, 8:30 a.m. to 5:30 p.m.

The contact information for the Office of Disability Services is:
The University of Texas at Dallas, SU 22
PO Box 830688
Richardson, Texas 75083-0688
(972) 883-2098 (voice or TTY)

Essentially, the law requires that colleges and universities make those reasonable adjustments necessary to eliminate discrimination on the basis of disability. For example, it may be necessary to remove classroom prohibitions against tape recorders or animals (in the case of dog guides) for students who are blind. Occasionally an assignment requirement may be substituted (for example, a research paper versus an oral presentation for a student who is hearing impaired). Classes enrolled students with mobility impairments may have to be rescheduled in accessible facilities. The college or university may need to provide special services such as registration, note-taking, or mobility assistance.

It is the student's responsibility to notify his or her professors of the need for such an accommodation. Disability Services provides students with letters to present to faculty members to verify that the student has a disability and needs accommodations. Individuals requiring special accommodation should contact the professor after class or during office hours.

Religious Holy Days

The University of Texas at Dallas will excuse a student from class or other required activities for the travel to and observance of a religious holy day for a religion whose places of worship are exempt from property tax under Section 11.20, Tax Code, Texas Code Annotated.

The student is encouraged to notify the instructor or activity sponsor as soon as possible regarding the absence, preferably in advance of the assignment. The student, so excused, will be allowed to take the exam or complete the assignment within a reasonable time after the absence: a period equal to the length of the absence, up to a maximum of one week. A student who notifies the instructor and completes any missed exam or assignment may not be penalized for the absence. A student who fails to complete the exam or assignment within the prescribed period may receive a failing grade for that exam or assignment.

If a student or an instructor disagrees about the nature of the absence [i.e., for the purpose of observing a religious holy day] or if there is similar disagreement about whether the student has been given a reasonable time to complete any missed assignments or examinations, either the student or the instructor may request a ruling from the chief executive officer of the institution, or his or her designee. The chief executive officer or designee must take into account the legislative intent of TEC 51.911(b), and the student and instructor will abide by the decision of the chief executive officer or designee.

Off-Campus Instruction and Course Activities

Off-campus, out-of-state, and foreign instruction and activities are subject to state law and University policies and procedures regarding travel and risk-related activities. Information regarding these rules and regulations may be found at the website address given below. Additional information is available from the office of the school dean. (http://www.utdallas.edu/Business_Affairs/Travel_Risk_Activities.htm)

These descriptions and timelines are subject to change at the discretion of the Professor.